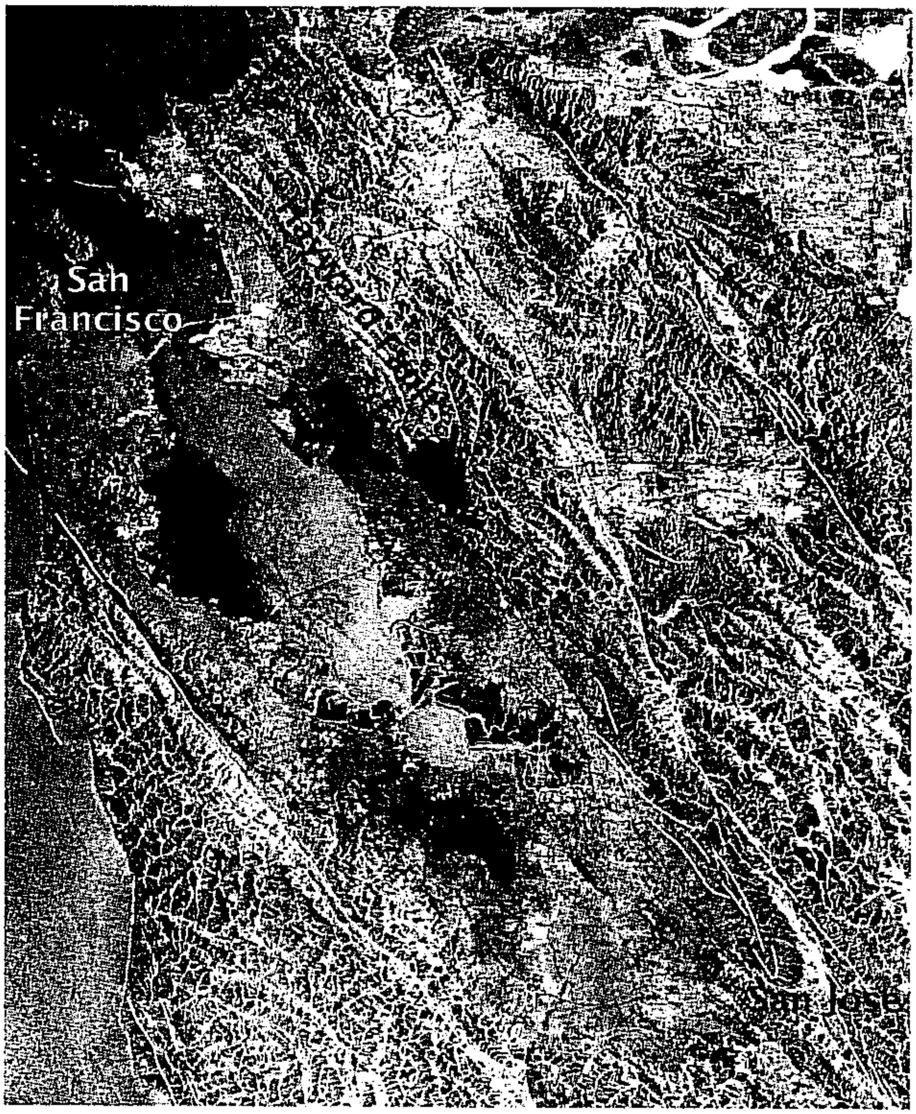
Reiners

Shuguang Liu

1998 FALL MEETING

American Geophysical Union



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H31E-02 0845h INVITED

Regional features of vegetation-atmosphere interactions in GCM sensitivity Studies

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To understand the influences of vegetation boundary conditions on the regional climate, and theunderlying mechanisms responsible for such a relationship, coupled global/regional models witha biosphere model (SSiB) are used to conduct a number of regional interaction studies, including equatorial North Africa, Amazon, East Asia, and US. The interactions between land andatmosphere are a nonlinear process. In addition, GCMs and regional models have internal variability. These factors make it difficulty to distinguish the land effect in a complex climate system. In our sensitivity experiments, the local vegetation conditions in the experiments are dramatically altered.; multiple ensemble simulations with different initial conditions are used, and only monthly and/or seasonal means are used for analyses. These designs are intended identify the signals due to land effects. Our regional studies demonstrate the important role that the landsurface plays in the regional climate. However, the manner in which a given boundary anomaly influences the circulation and rainfall for any particular region depends on the structure of the large scale flow for that region and the presence/absence of other quasistationary forcing (viz orography and ocean heat sources and sinks in that region). For example, in the Sahel study, thedesertification in the region changes the northward movement of the African monsoon, causing drought in the Sahel and wet climate to the south of the area. s a wellknown Sahel droughtpattern. Preliminary results also reveal the opposite phases of rainfall anomalies in Sahel andEast Africa. In the U.S. summer prediction study, the rainfall anomaly in the central U.S. is nearly limited within the area where the land surface anomaly forcing occurred. Thecharacteristics in East Asia are quite different from other areas due to a strong summer Asian monsoon and complex orography in the East Asian region. In two east Asian experiments, although the locations of the land anomaly forcing are different, both experiments show that the temperature anomaly is mainly confined to the area where anomaly forcing occurs, but the monsoon (not in the area where the land condition changes) has a large change. These studies show that the characteristic of land surfaceatmosphere interactions has a strong regional dependence, thus, different regions have to be studied separately to investigate the impact of land surface processes.

H31E-03 0900h INVITED

Derivation of Global 1 km Fractional Vegetation Cover and Its Impact on Climate Modeling

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Global 1 km fractional vegetation cover is derived based on the maximum NDVI value for each pixel during the 12 months in comparison with the maximum NDVI value in each IGBP land cover category. This product is then compared with an independent product using a more sophisticated statistical approach. Both products are evaluated and validated using higher-resolution data over southern Arizona. The impact of these data on climate modeling is evaluated using NCAR CCM3 in which fractional vegetation cover is empirically specified.

At the meeting, the global distribution of fractional vegetation cover from the above data analysis and its impact on CCM3 climate modeling at regional and global scales will be discussed.

H31E-04 0915h

Simulated Impacts of Historical Vegetation Change on Global Climate

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This study explores the global climatic impacts due to historical, anthropogenic land cover changes. We used the National Center for Atmospheric Research Community Climate Model 3 (NCAR CCM3) general circulation model and compared a simulation with present day land surface boundary conditions with a simulation representing an estimate of natural, potential land cover conditions.

After 10 years of simulation, significant temperature and hydrology changes affected tropical land surfaces, where some of the largest historical disruptions in vegetation characteristics have occurred. Also of considerable interest because of their broad scope and magnitude were changes in high latitude Northern Hemisphere winter climate which resulted from changes in tropical convection, upper-level tropical outflow and the generation of low-frequency tropical waves which appeared to propogate to the extratropics. These effects combined to move the Northern Hemisphere zonally averaged westerly jet to higher latitudes, broaden it, and reduce its maximum intensity thereby affecting midlatitude winter weather patterns under current land cover. Low-level easterlies were also reduced over much of the tropical Pacific basin while positive anomolies in convective precipitation occurred in the central Pacific indicating the possibility of an interaction between circulation changes related to El Nino-Southern Oscillation (ENSO) and those caused by tropical land cover change. Globally-averaged changes were small.

Comparisons with recent, observed trends in tropical and Northern Hemisphere, mid-latitude climate suggest a possible interaction between the climatic effects of historical land cover changes and other modes of climate variability.

H31E-05 0930h

Effects of Land-use Differences on Atmospheric Boundary Layer Circulations

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It has been widely postulated that variations in vegetation and other surface characteristics together with the resulting variation in surface heat fluxes will lead to secondary circulations in the atmospheric boundary layer. It has been further argued that failure to explicitly account for these circulations will routinely cause significant errors, for example, in the mean heat fluxes calculated for a GCM grid cell and in modeled formation and distribution of clouds. During the past several years we have used a combination of observations and modeling to investigate the effects of the underlying heterogeneous surface on boundary layer structure at the U.S. Department of Energy's Cloud and Radiation Testbed (CART) in the Southern Great Plains of the U.S. The CART site is a rectangular region approximately 300 km x 360 km in northern Oklahoma and southern Kansas. It is a region of generally gentle topography and of strong spatial contrasts in surface vegetation and heat fluxes.

There are extensive surface measurement networks in the vicinity of the CART from which we have been able to construct interpolated wind and temperature fields with time and space intervals of 30 min. and 6.25 km, respectively. In this study, we have composited wind data by time of day in order to minimize the masking effect of synoptic-scale weather events. To investigate the development of secondary circulations, we have used the composited fields to compute divergence patterns which can then be related to the underlying surface. We have done this for both the spring and the summer, since there is a marked changed in vegetation and in the heat flux distribution between these two seasons. The results of this study indicate, first, that secondary circulations are very weak. The associated divergences are comparable to those of synoptic-scale weather systems. Moreover, the topography, while gentle, nevertheless appears to be the primary factor in generating the local divergence fields. We therefore conclude that mesoscale fluxes resulting from land-use differences in this region will be inconsequential sources of error in GCM parameterizations of the boundary layer.

H31E-06 0945h

Do Mesoscale Circulation Induced by Deforestation Play Any Role in Triggering Moist Convection?

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The objective of this research is to identify atmospheric conditions unde r which mesoscale circulation induced by land surface heterogeneity may p lay some role in triggering of convection and occurrence of rainfall. A s eries of numerical simulations using MM5 have been carried out to further study the role of atmospheric stability and the relative importance of s ynoptic vs local forcing to the moist convection and rainfall over defore sted Amazon regions. In the dry-season simulations, no rainfall and littl e clouds are observed over both uniform and heterogeneous land surfaces. Heavy rainfall and extensive cloud coverage are found in the wet-season s imulations over uniform and heterogeneous land surfaces even when a negat ive energy barrier was added to the sounding. During the "break-period" with reduced large scale forcing, more active moist convection is observ ed in the afternoon over the deforested area. These results suggest that the local forcing due to mesoscale circulation induced by land surface he terogeneity may play a significant role in triggering shallow convection only when there is lack of large scale forcing.

H31E-07 1015h

Investigating the Effect of Seasonal Plant Growth and Development in 3-Dimentional Atmospheric Simulations

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We introduced daily plant growth and development functions into the Biosphere-Atmosphere Transfer Scheme (BATS) coupled to the National Center for Atmospheric Research Regional Climate Model (NCAR RegCM) to simulate the effect of seasonal plant growth on atmosphere-biosphere heat, moisture, and momentum exchange. Energy, moisture, and momentum fluxes were studied over a maize agroecosystem at the scale of a 90 km atmospheric grid cell. Daily plant growth and development were incorporated into surface flux calculations by coupling a physiological crop model (CERES version 3.0) with BATS. CERES simulates daily plant growth and development as a function of both environmental conditions (temperature, precipitation, solar radiation, and soil moisture) and plant-specific genetic parameters. The BATS and CERES models at first were driven by the observed weather data and selected crop parameters (i.e., Leaf Area Index [LAI], canopy height) were validated against available field data. Growth and development functions from CERES were incorporated into BATS and the sensitivity of sensible and latent heat fluxes, and momentum flux to plant growth was quantified.

We ran the coupled RegCM/BATS over the conterminous United States domain at a resolution of 90 x 90 km to investigate the effect of seasonal agroecosystem processes on mesoscale atmospheric circulations over the central Great Plains of North America. During the extremely dry season of 1988, compared to the noninteractive control case, 20-35% changes in sensible heat and 30-45% changes in latent heat occurred in response to greatly reduced LAI and canopy height. Two to four degree C changes in surface and lower atmospheric air temperature resulted in response to such changes in surface fluxes. Mixing ratio and lower atmospheric winds were also affected. The magnitude of these changes had a distinct diurnal pattern. The differences between the control and realistic simulations were more pronounced during the dry 1988 growing season than the relatively normal 1991 season. We also examined separately the effects of changes in LAI and those of roughness length. We found that the inclusion of plant growth and development functions into RegCM/BATS configuration altered not only seasonal patterns of state variables (T, q, Tv), but also the interannual variability in the simulated results.

H31E-08 1030h

Land Use Changes in Costa Rica's Atlantic Zone: Net Effects on N2O Emissions

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Land use changes affect net emission rates of greenhouse gases as well as alter micro- and mesoclimatological variables. Thus land use change has an indirect influence on climate over the long term as well as a direct one in the immediate term. Conversion of forested land cover in the wet tropics to agricultural uses has large effects on fluxes of CO2, CH4, N2O and NO. We are addressing the effects of rapid land use change on biogenic trace gas emissions in northeastern Costa Rica (the Atlantic Zone), a model region representing rapid land use change in hot, humid, and relatively fertile, tropical environments. In the last five decades, this region of 500,000 ha has been largely deforested and converted to pasture, banana plantations and other intensively fertilized crops. These changes have grossly altered biogenic trace gas emissions in complex ways in time and space making difficult the assessment of net changes in gas emissions for the region as a whole.

Our work involves linkage of direct measurement of N2O emissions, model development and assembly of requisite GIS layers and statistical approaches to estimate land cover changes on regional emissions from the Atlantic Zone. Our "contemporary" representation of land cover/land use is derived from a 1996 TM scene; our historical representations are from a land use atlas for the years 1979 and 1992. We have set several scenarios for future land cover/land use change for the year 2010 that assume different levels of land use through continued clearing and draining of swamps, and through continuing conversion of extensively managed pastures to crops requiring large amounts of fertilizer. From these changing levels of N2O, we can assess the relative importance of land use change in wet tropics on changing levels of N2O in the atmosphere.

H31E-09 1045h

The Evaporation Paradox

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At least three studies of field data have shown independently that the evaporation of water, as measured by evaporation pans, has been decreasing over large areas with widely different climates. The common interpretation of this negative trend has been that it might be related to increasing cloudiness and that it provides an indication of decreasing potential evaporation and of decreasing terrestrial evaporation component in the hydrologic cycle. This runs counter to well substantiated increases in precipitation and clouds as well as global circulation calculations with increasing atmospheric CO_2 which indicate an accelerating hydrologic cycle. In this presentation we resolve this paradox by showing that decreasing pan evaporation provides, in fact, a strong indication of increasing terrestrial evaporation.

H31E-10 1100h

Comparison of the Climatic Effects of Maximum Vegetation Change to the Changes Associated with a Doubled Carbon Dioxide Concentration

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Vegetation is an important component of the global climate system but the issue of vegetation change has mostly been neglected in studies of the enhanced anthropogenic greenhouse effect. Here, we quantify the maximum possible effect of vegetation on the global climate and compare it to the changes associated with a doubling of atmospheric CO2. The following set of simulations with the ECHAM-4 atmospheric General Circulation Model (GCM) is performed: in the global desert simulation, land surface properties are selected to resemble a desert at all nonglaciated land regions, while in the global forest simulation all parameters are set to ones representing evergreen forest with maximum soil moisture recycling capability. Both simulations are conducted under present-day and doubled CO2 concentrations. All simulations are intercompared, enabling us to compare the climatic differences of maximum land use change (i.e., global desert - global forest) with CO2 doubling, but also, the effect of maximum land use change under different CO2 concentrations. We find that the climatic changes of CO2 doubling and maximum land use change are comparable in magnitude but that the patterns of change are distinctively different. While doubling of CO2 primarily affects the higher latitudes, land use change has its strongest impact in the tropics. The climatic sensitivity to CO2 doubling is decreased in the global forest implying that vegetation weakens the effect of global warming. We conclude that the climatic changes associated with enhanced CO2 can considerably depend on the state of the vegetation which in turn is itself altered by humans through land use change.

H31E-11 1115h

Dynamic Global Vegetation Modeling for Prediction of Biogenic Trace Gas Fluxes

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A Dynamic Global Vegetation Model (DGVM) has been developed as a new feature of the NASA-CASA (Carnegie Ames Stanford Approach) ecosystem production and trace gas model (Potter and Klooster, 1997). This DGVM includes seasonal phenology algorithms calibrated using global interannual data sets from the AVHRR satellite "greenness" index. The coupled CASA-DGVM design is based conceptually on two main elements of Tilman's (1985) resource-ratio hypothesis of vegetation change, namely (1) plant competition for resources (water and light) over relatively short time periods of months and seasons, and (2) the long-term pattern in the supply of growth-limiting resources such as water and nutrients, i.e., the resource-supply trajectory. The model generates global gridded estimates of primary production, aboveground biomass, leaf area index (LAI), and trace gas fluxes. Eight test locations for the DGVM were evaluated initially to represent a variety of climate conditions ranging from Arctic to tropical and sub-tropical latitude zones. At all test locations, the predicted plant functional type (PFT) matched closely with the actual reported PFT. In the process of running the model to steady state PFTs, most forest locations showed a rapid progression of transient states, from bare ground to grassland, to grasses with shrub cover, and finally to the forest PFT. From this first global application, the DGVM correctly predicts the presence of forest classes in about 75 percent to 95 percent of all cases worldwide, and grasslands in about 58 percent of all cases. Effects of two hypothetical climate change scenarios were evaluated. Scenario I was set by warming air surface temperatures linearly to 4° C above average over a 25 year simulation period. Scenario II was set by decreasing annual rainfall amounts linearly to 50 percent below average over a 25 year simulation period. The warming scenario I resulted in PFT at high-latitude forest and boreal forest sites changing to mixed coniferous forest, accompanied by increase in canopy LAI. The drought scenario II resulted in PFT at the boreal forest and savanna sites changing to grasslands. At locations where PFT did not change with climate, soil water and canopy LAI however were predicted to progressively decline under the warming scenario beginning from steady state temperate and tropical zone PFTs, and also under the drought scenario beginning from practically any steady state PFT.

H31E-12 1130h

Biosphere-Hydrosphere Interactions: Biogeochemical Constraints on Evapo-Transpiration in the South Platte River Basin

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Our understanding of the interactions between the atmosphere and the land surface is critical to our estimation of the vulnerability of key natural resources to climate and land use changes. Changes in these interactions affect mesoscale physical and chemical climate, water basin hydrology, and ecological properties, such as vegetation composition, disturbance regime, and biogeochemical cycles. The terrestrial biospheric processes are controlled by biogeochemical constraints as well as by atmospheric, hydrological, and management constraints. The surface hydrological process, such as runoff, run-on, percolation, snowpack accumulation, snow melt, and evaporation, are strongly linked to terrestrial biospheric processes. In addition, the land surface coupling with the climate system is mediated by changes in the hydrosphere through changes related to evapo-transpiration (ET), trace gas fluxes, and modification of surface winds. Recognition of the feedbacks between the atmosphere, hydrosphere, and the terrestrial biosphere has led our research efforts to begin quantifying these feedbacks and constraints. The current findings indicate that land surface characteristics of terrestrial ecosystems modify the seasonal patterns of the hydrological system due to changes in the onset of greening, amount of photosynthetic material, and rooting depth. These feedbacks operate rapidly and are estimated many times each hour. Biogeochemical and ecosystem interactions with atmospheric and hydrological processes operate over a longer time frame, but alter critical water-energy fluxes that affect the climate system. The ecosystem modeling of actual land use and biogeochemical constraints in our ecosystem reduces the leaf area and plant productivity by 30 to 50% of a system not biogeochemically constrained.

H31E-13 1145h

The Effects of Vegetation Changes on the West African Monsoon

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West Africa has experienced dramatic land surface changes throughout the 20th century. The edge of the Sahara Desert has experienced significant human impacts. In addition, extensive deforestation has occurred along the southern West African Coast. Previous efforts by this group, using a simple zonally-symmetric model, have shown that these vegetation changes may have a substantial impact on the regional climate of West Africa. In this study, we use a regional climate model to compare the effects of desertification and deforestation on the West African monsoon. This effort is important to understand the role that vegetation changes have played in the West African drought that has been observed since the early 1960s.

We use NCAR's regional climate model (RegCM2) to examine the climatic response to desertification and deforestation in West Africa. The model domain includes West Africa and the adjacent Atlantic Ocean. NCEP Reanalyses are used to initialize and drive the model. We will present results from a series of year-long model experiments in which the vegetation is varied to mimic the observed land surface changes. In different simulations, the vegetation changes associated with desertification and deforestation are represented separately and together, so that the climatic response to each forcing is isolated and feedbacks between the forcings can be identified.

H31F MC: 300 Wednesday 0830h
Monitoring and Modeling of the Performance of Engineered Covers for Waste Isolation I

Presiding: B Scanlon, University of Texas at Austin; G Gee, Pacific Northwest National Laboratory

H31F-01 0830h

Closure Cover Design Criteria for Low-Level Radioactive Waste Landfills: Dealing with Waste Subsidence

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Existing low-level waste radioactive waste (LLW) disposal units at the Nevada Test Site are expected to exhibit substantial subsidence over the next 100 to 10,000 years. The maximum predicted subsidence, which results primarily from the degradation of partially filled containers in a disposal unit, ranges from 10 to 50 feet for various units at the facility. This magnitude of subsidence could significantly affect the performance of a closure cover, especially considering that the subsidence is not expected to be uniform throughout an individual unit.

This talk will summarize how a preliminary closure cover design was developed for LLW disposal units at the Nevada Test Site. First, a set of engineering performance criteria was established: (1) limit exposure of waste at the ground surface; (2) limit water infiltration into the waste; (3) limit upward gas migration; and (4) limit intrusion of plant roots and animals into the waste. For each criterion, objectives were identified and quantitative standards were established to meet these objectives. These criteria and quantitative standards for the closure cover are an important contribution because regulations require only that the overall disposal system meet Performance Assessment (PA) requirements. Disposal units at the Nevada Test Site could easily pass the PA even if no closure cover were placed over the waste due to the isolated, arid nature of the site. The engineering performance criteria provide quantitative standards for the closure cover in addition to requiring that the overall system pass the PA. Second, alternative designs were analyzed within the context of these engineering performance criteria. Based on these analyses, a preliminary, conceptual design was developed that would be expected to meet these criteria even if the maximum predicted subsidence were to occur.

H31F-02 0845h INVITED

Strategies for Monitoring Soil Water Conditions at Waste Disposal Sites

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As part of a large field, study four subsurface monitoring strategies were tested during field infiltration and tracer transport experiments (area = 50 m by 50 m) at a site in Maricopa, Arizona. The purpose of the experiments was to test strategies and systems for monitoring unsaturated zone conditions at radioactive waste disposal sites. For each strategy (e.g., monitoring trenches, monitoring islands, borehole monitoring and geophysical monitoring) used a variety of devices to determine changes in water contents with time and space. We combined intrusive (neutron probe, heat dissipation sensors, tensiometers, solution samplers) and non-intrusive instruments (EM-31, EM-38) for